FIRST YEAR RESULTS OF THE SUGAR BEET TRIALS IN THE NATAL MIDLANDS

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Abstract

The results for the first season of a three-year feasibility study on sugar beet production in Natal are presented. Serial plantings from October to March at four localities, ranging in elevation from 1 070 m at Seven Oaks to 1 660 m at Kamberg, show that the main problem likely to be encountered in sugar beet production is Cercospora leaf spot. The highest sucrose yields (8 to 15 tons/ha) were obtained at Kamberg and the lowest (7 to 11 tons/ha) at Seven Oaks. Leaf spot incidence was greatest at Seven Oaks and lowest at Kamberg. Sucrose yield decreased as the planting date was advanced. Roots failed to reach a harvestable size in crops planted after January. November plantings were most affected by leaf spot while plantings in early October, late December and January escaped the effects of the disease to a greater or lesser degree. Sucrose content of roots remained low during summer and autumn but rose to values of between 17 and 20% in August. Root mass remained stable during the period of sucrose accumulation.

Introduction

Sugar beet is considered to be a crop most suited to the temperate climates of latitudes ranging from 40°N to 45°N. In practice, however, sugar beet is grown successfully under a much wider range of climates so that beet sugar industries are now found in several countries south of the 35°N parallel, such as Israel, Pakistan and Arizona, USA, where air temperatures may exceed 35°C.

Numerous efforts are at present being made to grow sugar beet outside the traditional areas. The primary concerns of such attempts are usually to establish potential yields and optimum planting and harvesting periods.

Sugar beet does not have a limited growth cycle except as dictated by the weather, and the best planting and harvesting times are those that afford the longest period of net accumulation of carbohydrates in the roots. The most common planting period in North America and in Europe is early spring, after much of the danger of severe frost is passed. In warmer climates planting may occur at any time of the year. Jackson and Carasso[6] found that spring plantings were not successful in Yuma, Arizona, because of high temperatures which resulted in poor germination and favoured the proliferation of insects and diseases. Autumn plantings, by contrast, kept well over winter and grew rapidly in early spring before conditions became favourable for overwhelming insect and disease infestation. It was found necessary to lift the crop before August to avoid a drop in sucrose content and high costs in controlling diseases.

An autumn to mid-summer cycle was found best for sugar yields in the Punjab, Pakistan (Fashi *et al*[2]). The highest yields were obtained from crops that were the first to be sown (15th September) and the last to be lifted (15th June). Similarly, in Libya, the autumn-winter growth cycle was superior to the spring-summer cycle and afforded a growth season of 225 days as opposed to 150 days (Lionti[9]).

Sugar beet has only one foothold in the southern hemisphere viz., Chile, but many countries south of the equator have shown interest in the crop. Plans for a sugar beet industry in New Zealand appear to be developing well after a three-year feasibility study on growing beet in mid-Canterbury. Average yields at five localities ranged from 47 to 53 tons of roots per hectare at 16,7 and 20,1% sucrose. The industrial yield is predicted as 37 tons of roots per hectare at 18% sucrose. September to October is regarded as the best planting time (Starke[14]).

Sugar beet has occasionally been considered in South Africa since the turn of the century. It is reported from Cedara that trials between 1904 and 1906 showed that drilling in January gave up to 46 tons of roots per hectare with sucrose ranging between 13 and 16% of the root mass (Rose [13]). Four growth cycles were tried in a sugar beet trial at Shakaskraal in 1960/61. The highest root yield (67 tons/ha) was achieved by planting in July and harvesting in January although sucrose content was highest (16,2%) in the March to November cycle (Rose[13]). Kraft[7] grew nine varieties of sugar beet in a trial at Potchefstroom in 1970. Yields ranged from 36 to 54 tons of roots per hectare and the sucrose content was 10,2% on average. There were slight infestations of aphids and fungal diseases (*Alternaria* sp and *Cercospora* sp), but the potential for the crop in the area was regarded as high.

This paper reports the results of the first season of a three-year project to assess the feasibility of growing sugar beet in the Natal Midlands.

Four sites were chosen for the serial planting of three varieties of sugar beet in replicated trials, while ten other sites were selected for a spring and autumn sowing of one variety viz., Nomo. These observation trials served mainly to demonstrate how widespread leaf spot (*Cercospora beticola*) is likely to be in Natal. The results from the replicated trials only will be discussed.

Methods

Planting procedure

Details of the four sites selected for replicated trials are given in Table 1. These sites represent the main climatic range considered to be suitable for sugar beet in Natal. More details

TABLE 1
Characteristics of sugar beet experiment sites

Locality	Farm	Bioclimatic Group*	Mean Annual Rain (mm)*	Mean Annual RH %*	Elevation (m)	Soil Series	Adjusted pH (water)
Kamberg	Solitude	Highland	850–1 100	70–75	1 660	Doveton	5,8
Mooi River	Rondebosch	Montane 4 e	850–1 100	70–75	1 520	Doveton	5,7
Howick	Woodlands	Mistbelt 3 c	800–1 000	65–75	1 300	Griffin	5,7
Seven Oaks	Harden Heights	Mistbelt 3 a	800–1 650	75–80	1 070	Farningham	5,5

* Phillips[12]

TABLE 2
Planting dates of trials at four sites

Locality	Planting sequence							
	1	2	3	4	5	6	7	8
Kamberg	8/10/75	31/10/75	19/11/75	17/12/75	7/1/76	2/2/76	16/2/76	11/3/76
Mooi River	8/10/75	29/10/75	19/11/75	23/12/75	18/2/76	10/3/76		
Howick	7/10/75	30/10/75	18/11/75	8/12/75	27/2/76	10/3/76		
Seven Oaks	9/10/75	31/10/75	20/11/75	22/1/76	16/2/76	16/3/76		

on the climate and soils of these and the observation sites are given by Meyer and Wood[11].

Lime was applied at each locality except at Howick, in order to reduce soil acidity to a pH (water) of 5,8. Superphosphate (8,3% P) was incorporated at 1 000 kg/ha before planting and 90 kg/ha each of nitrogen and potash were applied at the time of planting.

Seeds were drilled 18 to 30 mm deep, in rows 50 cm apart, and plants were thinned to five to a metre of row. Temik 10G was applied in the furrow at 30 kg/ha. Weeds were controlled by hand.

Treatments

Planting date and variety were the two variables under consideration. Eight planting dates from October 1975 to March 1976, at 21 day intervals, were planned. The unusually wet conditions from December to April resulted in only six to eight somewhat irregular plantings being undertaken per site (Table 2). Nevertheless the first four plantings adhered fairly well to the plan.

Seed of the four varieties, Sharpes Klein poly, Kawemegapoly, Nomo and Bush Mono G were imported, but Nomo was planted in plots allotted to Bush Mono G, which failed to meet phytosanitary requirements. The planting depth in these plots was 6 mm deeper than in the other plots but the deeper planting had no consistent effect on yields.

Each planting consisted of four treatments replicated three times.

Sampling procedure

In order to minimize the effect of plant population on yield, root samples were taken from only those portions of each plot where the population exceeded two plants per metre of row. Variations in population between 65 000 and 100 000 plants per hectare are considered to have very little effect on yield (Hull and Jaggard[5]).

Sampling was carried out after four months of growth, at 14 day intervals up to the 23rd June, 1976. Two further samples for sucrose determination were taken on the 3rd and 30th of August. On each sampling occasion, the beet growing in a one square metre area in each plot was lifted. The plant populations in the second planting at Howick and the fourth at Kamberg were too uneven to permit the sampling of individual plots. All other plantings were sampled on an individual plot basis on five or more occasions, except the second planting at Kamberg which was sampled four times. When any plot in a trial no longer had a portion representing a complete stand, the planting would be sampled by removing the beet from five separate square metre quadrats from any part of the stand.

Tops and roots were separated, washed and weighed. The roots were analysed for sucrose and dry matter content and the purity of the fresh beet juice was determined.

The first four plantings in each locality were the only crops to reach a havestable stage. Results are thus based primarily on these plantings.

Results and discussion

Pests and diseases

Infection by *Cercospora beticola* (leaf spot) started to appear in mid-January and, six weeks later, all the early plantings were severely affected. Such widespread and virulent occurrence of a fungal disease in the first year of sugar beet cultivation in Natal was surprising, although the long periods of wet weather undoubtedly hastened the spread of the disease. Benomyl was applied as a foliar spray to two of the three replications in each trial, after the stage where most plants were infected.

Root rot *(Rhizoctonia solani)* occurred sporadically in most plantings but reduced plant populations severely at Mooi River. Infection was severe in the first planting, very severe in the second, moderate in the third and almost absent in the fourth planting. The fifth planting had patches of infected beet while the sixth was free of the disease. This trend is ascribed to variations in soil moisture during the season.

Root knot nematode (*Meloidogyne* sp) was not entirely absent from the replicated trials despite the precautionary measure of applying a nematicide. The problem was very serious in some of the observation plots and it is clear that nematodes will have to be controlled, even in heavy soils, if sugar beet is to be grown successfully.

Leaf feeders such as adults of white grub *(Adoretus fasculus)* proliferated in January but were easily controlled with insecticides.

Varieties

The period during which all 12 plots in a trial were sampled was divided in two, and average values for root, top yield and root/top ratio were obtained for each plot in each period. The analysis of variance for each period, planting and locality revealed no difference between varieties in regard to root and top yield.

Sharpes Klein poly had a slightly higher sucrose content (13,1%) than Kawemegapoly (12,9%) and Nomo (12,9%). This ranking applied to 33 of the 56 comparisons that were made. No difference in juice purity between varieties could be detected.

The most important difference between the varieties lay in the nature of their seed (Table 3). Nomo, being genetically monogerm, had a low percentage of clusters, with two seedlings. The percentage was higher for Sharpes Klein poly (16%), which is technically monogerm and very high for Kawemega-

TABLE 3
Germination and emergence of sugar beet clusters

Variety	Germination (%)	Clusters with 2 seedlings (%)	Seedling emergence, mean of March plantings (%)
Sharpes Klein Poly	53	16,2	63
Kawemegapoly	75	42,8	68
Nomo	80	10,0	87

poly (43%) which is multigerm. All else being equal, Nomo would be preferred to the other varieties because it gave stands that were more even and easier to thin.

Fungicide treatment

The advent of leaf spot resulted in an additional variable in the trials, in the form of degree of disease control. The two sprayed replications, in the first four plantings at each locality, were not free of leaf spot but were markedly superior in appearance to the unsprayed replication (Fig. 1).

FIGURE 1 Sugar beet treated (foreground) and untreated (background) with fungicide.

At the end of March 1976, top mass had been reduced by 14, 21, 35 and 55%, in plantings 1 to 4 repectively, by withholding fungicide treatment (Fig. 2). Root mass was not affected to the same degree and the average decrease due to lack of fungicide treatment was 4, 7, 26 and 37% of the mass of the sprayed plots for plantings 1 to 4 respectively. The deviation from this trend at Mooi River is ascribed to severe infection by root rot in the first two plantings. A significant correlation (r = 0,815**) existed between decrease in top mass and decrease in root mass due to lack of disease control. A 10% decrease in top mass was associated with a 6,7% decrease in root mass.

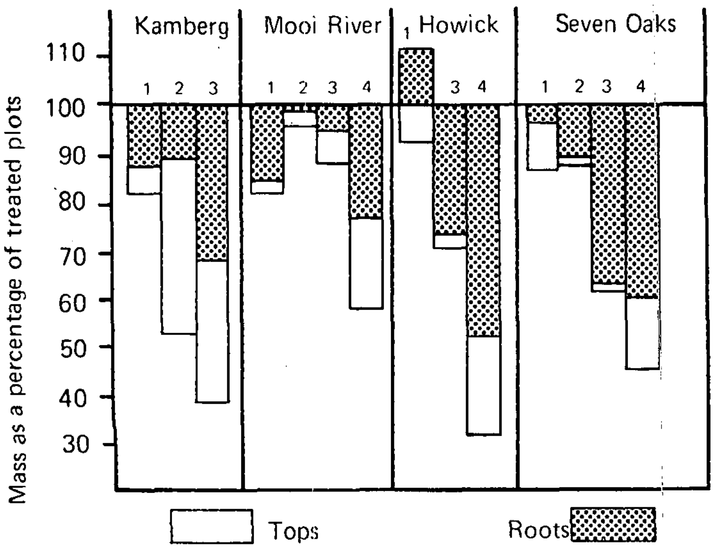

FIGURE 2 Decrement in top and root mass due to withholding fungicide treatment in serial plantings (numbered 1 to 4).

As there was no absolute control of leaf spot, the top yield trends illustrated in Fig. 3 present a problem of interpretation. Conditions for growth between December and April were nearly ideal, so that the rapid fall off in top mass over this period can be attributed largely to leaf spot infection. Top mass normally increases rapidly during the first four months of growth and thereafter stabilizes or declines slightly (Loomis *et al* [10], Follett *et al*[3]). Storer *et al*[13], by contrast, showed a 30% drop in leaf mass from peak values in August to mid-October in Colorado. The occurrence of frost reduced leaf mass to an even greater degree.

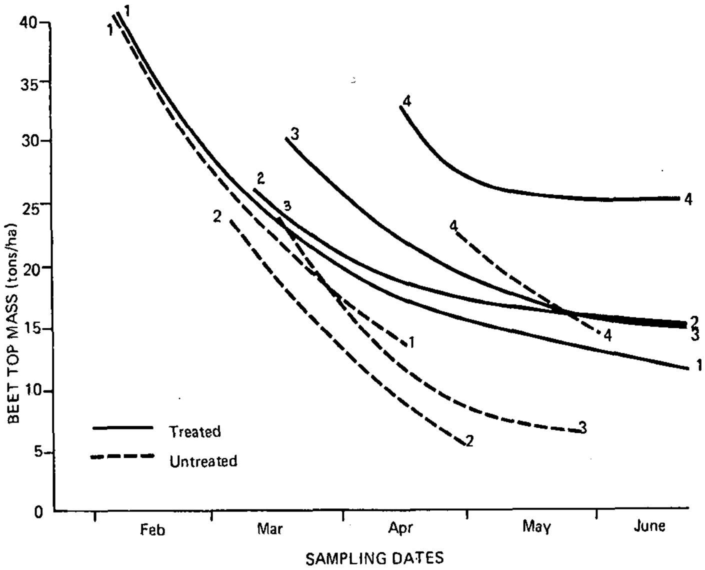

FIGURE 3 Mass of beet tops either treated or untreated with fungicide. Numbers refer to four serial plantings.

Top mass of the first three plantings fell by 58% from February to May but, in the fourth planting, the fall off was only 22% on average. It is probable, therefore, that the larger effect of fungicide application in the fourth than in the preceding plantings is due to treatment in the later plantings starting earlier, relative to the stage of growth, than in the first three plantings. In addition, it is clear that, irrespective of spraying treatment, the December-January plantings were less troubled by leaf spot than crops planted in October and November. At the end of May, tops of untreated beet planted in December and January were similar in size to tops of treated beet but about twice the size of untreated tops in the first three plantings. It is likely that the late plantings were fairly resistant to leaf spot at the time of its greatest virulence. Young sugar beet plants are known to be resistant to the disease, but the reasons for this are not clearly understood (Darpoux and Margara[1]).

Root growth

Sugar beet crops planted between October and December were broadly similar in regard to the rate of root growth (Fig. 4). Crops planted later than January grew less rapidly and

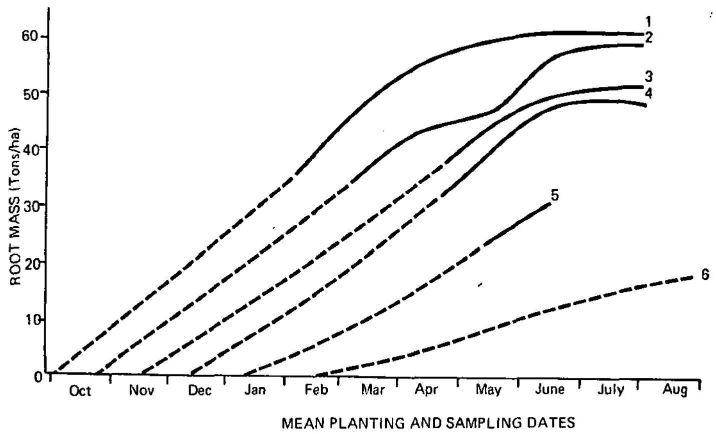

FIGURE 4 Root development in six serial plantings of sugar beet.

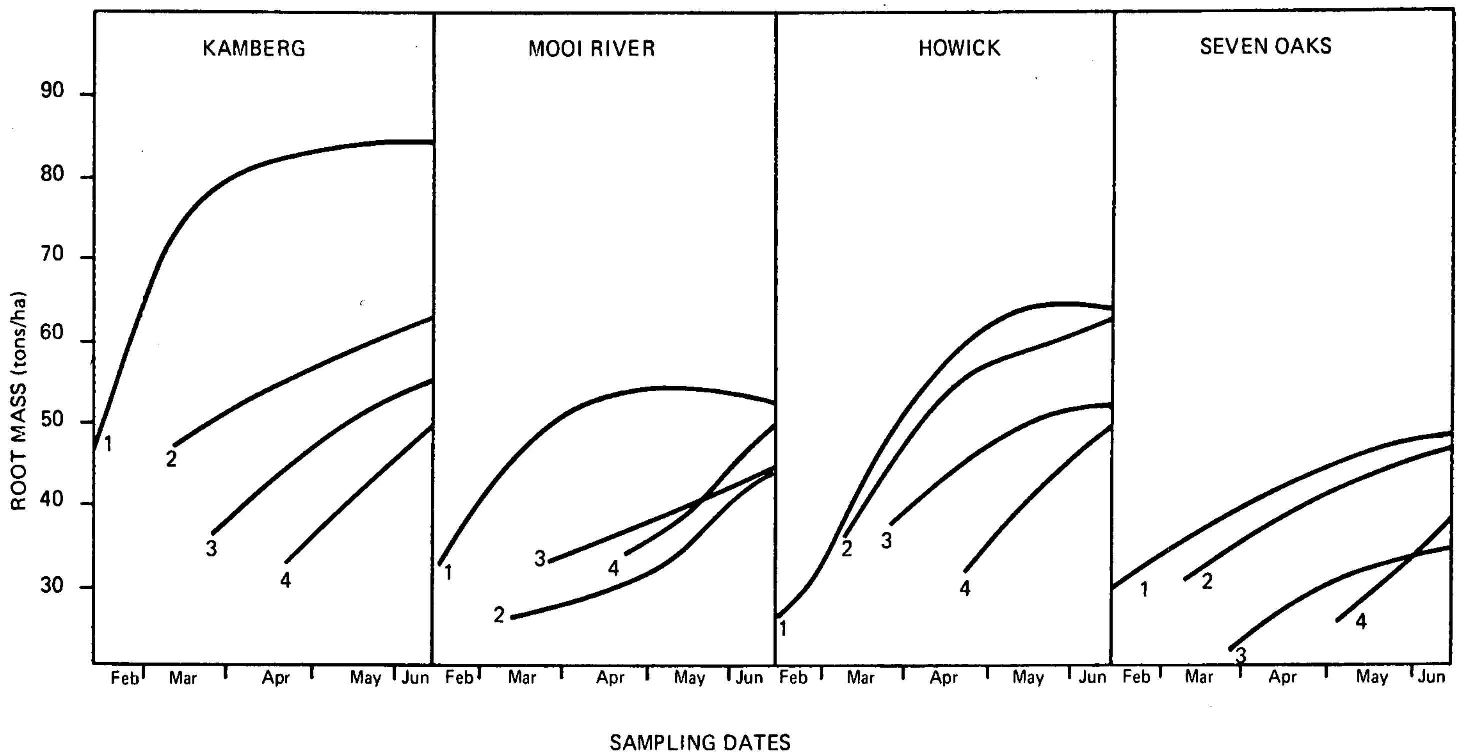

FIGURE 5 Root development of four serial plantings of sugar beet.

failed to reach a harvestable stage before the onset of winter frosts. Heavy frost in the Midlands, on the 22nd June and days following, reduced crowns of the sugar beet crops to small decumbent rosettes, and root growth apparently ceased. There was however, no evidence of a decline in root weight after this date.

Within the October to January planting period there was a tendency for early plantings to grow more rapidly than later plantings (Fig. 5). It is likely that the difference in root development between plantings reflect varying degrees of competition between crop growth and fungal parasitism. The crop from the earlier plantings tended to be larger and more vigorous at the stage when leaf spot began to spread, while the later planting produced smaller plants and appeared to suffer more damage. Root growth invariably increased with the fourth planting because of less favourable conditions for leaf and root rot later in the season.

The severity of leaf spot infection decreased with increases in elevation so that root growth was best at Kamberg and poorest at Seven Oaks. The first two plantings at Mooi River deviated from this trend because of the added restriction on growth by root rot.

The root yields in Table 4 are means of samplings taken after a consistent change in root mass could be detected. These values represent an estimate of potential yield and they conform to the trends discussed above. On average, there was a 5 ton/ha decrease in root yield for each 21 day delay in planting date.

TABLE 4
Mean root yield (tons/ha) of samplings taken once root mass appeared to be constant

Locality	Planting sequence				Mean
	1	2	3	4	
Kamberg .	85	59	52	45	60
Howick .	62	60	53	48	56
Mooi River	52	43	55	52	50
Seven Oaks.	45	60	41	38	46
Mean . .	61	56	50	46	53

Sucrose content

The sucrose content of beets at any stage in the season varied only slightly between plantings and between the localities of Kamberg, Mooi River and Howick. The sucrose content of beets at Seven Oaks remained considerably lower than at other localities until May, and thereafter rose rapidly to a value of 18% in August, which was common to all localities.

The change in sucrose content during the season is shown in Fig. 6. The co-efficient of variation of mean sucrose values from Seven Oaks was less than 5% and from the other localities combined, it did not exceed 2,5%.

The low sucrose content at Seven Oaks during summer and autumn is probably related to the relatively high temperatures that prevail in that area, indirectly through leaf spot infection

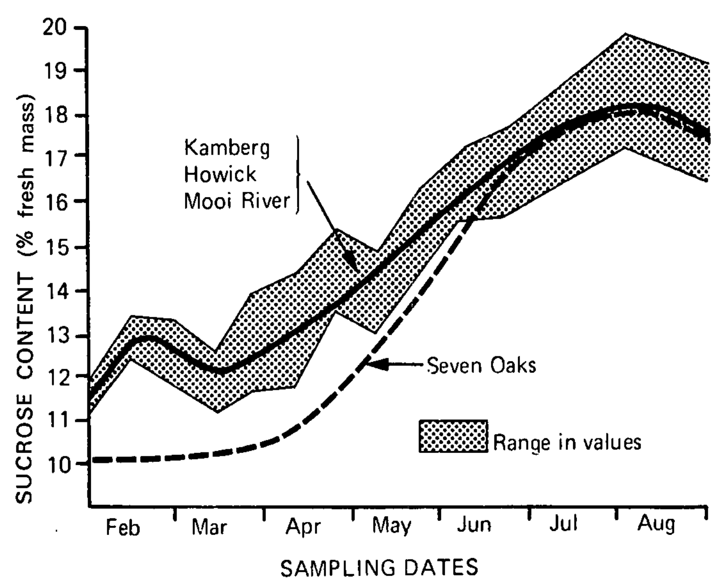

FIGURE 6 Seasonal pattern of beet sucrose content.

and directly through carbohydrate metabolism and distribution (Leopold[8]). At the other localities, sucrose content remained low during the summer while conditions for root top growth were favourable. The depression in sucrose content during March corresponded with a period of heavy leaf spot infection.

Climatic conditions in the Midlands between April and August proved to be nearly ideal for sucrose accumulation in the roots. The deep rooted crop made use of moisture stored at depth in the soil profile and the reduction in leaf area after frosts in June resulted in a reduction in evapotranspiration. The small but numerous leaves (sometimes as many as 50 per plant) were fully turgid throughout the dry period and were thus able to photosynthesize sufficiently to maintain root mass and accumulate sucrose.

Sucrose yield

Since the only appreciable variation in sucrose content was due to locality and the stage of sampling, values for sucrose yield per hectare followed the same trends as root yields, apart from the fact that sucrose yields continued to rise after May, once root growth had ceased. The net result of a gradual rise in the mass of roots at near-constant sucrose content during summer and autumn, and a steady rise in the sucrose content of roots of constant mass in the winter, was a linear increase of sugar yield per hectare over the sampling period. This linear relationship differed slightly between the four plantings and four localities under consideration. In general the sugar beet crop accumulated sucrose at the rate of 25 kg per hectare per day from February to August.

The sucrose yields shown in Table 5 are products of the estimated root yield and the peak sucrose content of the season, which is regarded as 18% for each planting at each locality. These values, of course, conform to the root mass trends discussed above. There is a loss of roughly one ton of sucrose per hectare for each 21 day delay in sowing. This is of the same order as the decrement in yield for each day's delay in sowing in Europe, which is 50 to 100 kg sugar/ha according to Hull and Webb ([4]).

TABLE 5
Mean sucrose yield (tons/ha)

Locality	Planting sequence				Mean
	1	2	3	4	
Kamberg .	15,3	10,6	9,4	8,1	10,8
Howick .	11,2	10,8	9,5	8,6	10,1
Mooi River.	9,4	7,7	9,9	9,4	9,4
Seven Oaks	8,1	10,8	7,4	6,8	8,3
Mean . .	11,0	10,1	9,0	8,3	9,5

Conclusion

The relatively high sucrose yields, ranging from 7 to 15 tons per hectare could augur well for sugar beet production in Natal. It must be pointed out that these estimates were obtained by sampling only completely populated stands, a situation which might prove difficult to achieve in commercial fields. There is little doubt that sugar beet requires more precision in the areas of seed bed preparation, planting, weed and eelworm control, and lime application than many crops grown on a large scale in South Africa. Sugar beet was found to be very sensitive to deficiencies in each of these aspects of crop husbandry. Rampant weed growth, high intensity rainfall, hail and insects all played a role in depleting the beet population during its seedling stage, which lasts a long time compared with that of other crops. One factor that was not limiting to growth this season was the availability of moisture in the soil. It remains to be seen how the sugar beet crop will perform in drier seasons.

The abnormally wet conditions would have resulted in above average yields if they had not been responsible, at least in part, for the virulence of leaf spot infection. Cercospora leaf spot is likely to be the most serious threat to sugar beet production in Natal, and future research should be directed towards finding a solution to this problem. The results suggest that, by planting early in spring, the crop is allowed to grow rapidly before the beginning of the main leaf spot period, which could then be spanned by a few applications of fungicide. Planting in December and January allows just sufficient time for roots to develop to a harvestable size and enables the crop to endure leaf spot infection during a more resistant stage. Apart from the use of planting date and fungicide treatment to solve the leaf spot problem, resistant varieties should be considered.

The winter climate of the Natal Midlands may prove to be the most important point in its favour as a suitable area for sugar beet production, if the plants can survive on the stored soil moisture of drier years. Weeds are killed by frost, diseases and pests appear to be absent, and the crop is able to develop without requiring expensive maintenance. The beets could be lifted over a comparatively long period starting in May and ending in August even September. Harvesting conditions during this period would be suitably dry.

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